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Dear Marty:

This is the sixth quarterly report on work done on Contract N00014-C-89-2238, for X-ray Mask Repair.

2.31 Advanced Column Development

The proof of concept column was assembled and put under vacuum on the column test stand. The pressure was 1 x 10^{-7} torr after a day of pumping with a turbopump.

The first experiment was to run the column using the same voltages as the commercial column. The accelerating voltage was 30 kV and the column was run in a decelerating mode with the 2nd lens potential lower than the 1st. Three critical results were achieved in the initial days of experimentation: 1) the column did not arc and it maintained voltages for serveral-hour periods at a time 2) the ion source was stable without feedback maintenance for several hours at a time 3) the resolution was only 2-4x worse than expected.

The next round of testing showed that the column is more easily aligned than a commercial 2-lens column and is much more stable(less sensitive to vibrations). These are important design considerations for X-ray mask repair.

Our next steps are to accurately measure the spot size and to operate the column in an optimum mode, namely to run the 2nd lens in acceleration mode.

2.32 Repair Processes

We investigated using a thin film of FIB deposited tungsten to improve imaging(by reducing the channeling). This is similar to a technique suggested by Al Wagner - he claimed that a thin film of sputtered tantalum of FIB deposited carbon improves imaging. Though the tungsten did reduce channeling in the image, the tungsten deposited too effectively on structures less than 0.5 um apart and distorted them. The technique does not appear promising.

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We started to repair real defects on a Hampshire Instruments X-ray mask. They provided us with two masks, SEM images of actual defects, and SEM images of the mask exposed to their X-ray source and then transferred into resists. We are repairing the defects, and then Hampshire will expose the masks and inspect the resist structures.

Software

We have been developing software packages for X-ray Defect Repair and for KLA defect data transfer. We are using a program based on the photomask defect repair software for the Defect Repair Program for the 0.5 um machine. The program will inherit the stability of the existing programs and yet will be flexible and will allow for more experimentation. For example, the user will be able to create plate files for each X-ray mask type, including calibration values for edgelocking, and for two imaging modes. The program can easily accomodate data transfer of image files.

The new data transfer program for translating KLA defect information (as well as other transfer format and media) involves rewriting of the existing data transfer program. A contracter was hired and will complete the task by mid-winter.

We have been having regular conference calls with KLA. The purpose is to review plans and requirements for providing Micrion with enough information to implement the mask repair machine to the system controller interface for UVIS. We've discussed alignment marks, defect and reference image storage and retrieval, and defect position accuracy requirements.

2.33 System Stability

A new ion source and positioning controls are being developed with the advanced column effort to minimize drift and instabilities associated with the source fixture. At present, the source fixture is long and narrow and susceptible to vibrations. The goal is a shorter, wider support structure. A new one is being designed.

2.34 Charge Neutralization

The new floodgun was run for several weeks on the X-ray mask repair system. Although we are making changes to allow better positioning control of the electron beam, the life-time of the new electron gun is as good if not better than the old one. The new gun did not appear to affect the tungten deposition process.

2.35 Imaging/Edge Analysis

The new edgelock algorithm, signal normalization, worked extremely well on photomasks and gave better edge accuracy/edge finding

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statistics than previously achieved. We tried it on an IBM X-ray mask, and as expected, we have problems with channeling phenomena which produces a mottled image. If the secondary signal over the gold is high (good contrast) then this edge finding technique works. If the secondary signal over the gold absorber is low (a dark image due to channeling) then the algorithm is not good.

We reduced the dwell time in electron mode to 3 microseconds (which is the pixel dwell time used for Multiplex imaging) and we achieve good images without severe channeling. Specifically we've found that the ideal dose for a usable image is 0.8-3 x 10^{-4} nC/um^2 or 0.5-2 x 10^{14} ions/cm^2. We are retesting the new edgelock algorithm on both IBM and Hampshire X-ray masks.

Other:

A quarterly review meeting was held at Micrion on November 29. Micrion requests help with the following items that were brought up in the meeting:
1. We need a programmed defect test pattern on a wafer or mask as soon as possible to test the accuracy of our machine.
2. We need IBM masks with known, typical defects so we can begin to repair real defects.
3. We need four reference marks on each mask for alignment purposes.
The next meeting is scheduled for Wednesday, February 27, 1991 at Micrion.

Sincerely

Diane K. Stewart

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X-ray Program Manager

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